MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2019/2020

ETM2156 – FUNDAMENTALS OF COMMUNICATIONS

(TE)

14 MARCH 2020
2.30 p.m. – 4.30 p.m.
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This question paper consists of 9 pages with 4 Questions and Appendices.
2. Attempt **ALL** questions. Each question carries an equal total mark and the mark distribution for each question is given.
3. Please write all your answers in the Answer Booklet provided.

Question 1

(a) Define communication system. Give three advantages of a digital communication system over an analog communication system.

[4 marks]

(b) Sketch two signals that one represents periodic signal and the other represents aperiodic signal. Name the common techniques used to analyze the spectral components of these signals.

[4 marks]

(c) Given a signal $g(t) = t^2$ is periodic over the interval (-1, 1). Find the trigonometric Fourier series to represent $g(t)$ for $0 \le n \le 4$.

[9 marks]

(d) From $X(f) = \int_{-\infty}^{\infty} x(t)e^{-j2\pi ft}dt$, find the Fourier Transform of the waveform y(t) shown in Figure Q1(d).

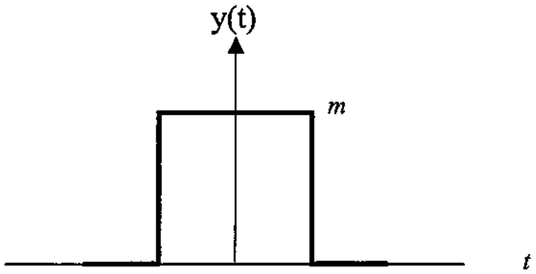

Figure Q1(d)

[4 marks]

(e) Based on the Fourier transform property for time shift that is given as $x(t-\tau) \Leftrightarrow X(f)e^{-j2\pi f\tau}$ and the Fourier transform found in part (d), find the Fourier transform of the rectangular function illustrated in Figure Q1(e).

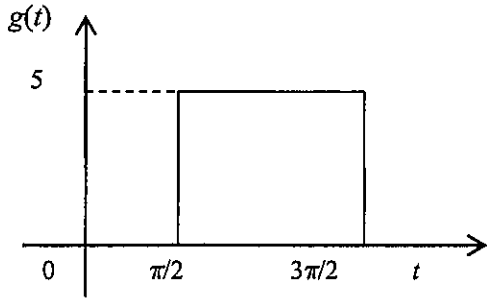

Figure Q1(e)

[4 marks]

Continued ...

Question 2

(a) Define the term modulation and give three benefits of modulation.

[5 marks]

(b) The message signal $m(t)$ whose spectrum is shown in Figure Q2(b) is passed through the system shown in the same figure. The bandpass filter has a bandwidth of $2W$ centered at frequency f_0 and the lowpass filter has a bandwidth of W. Plot the double-sided spectrum of the signals $x(t)$, $y_2(t)$, $y_3(t)$, and $y_4(t)$.

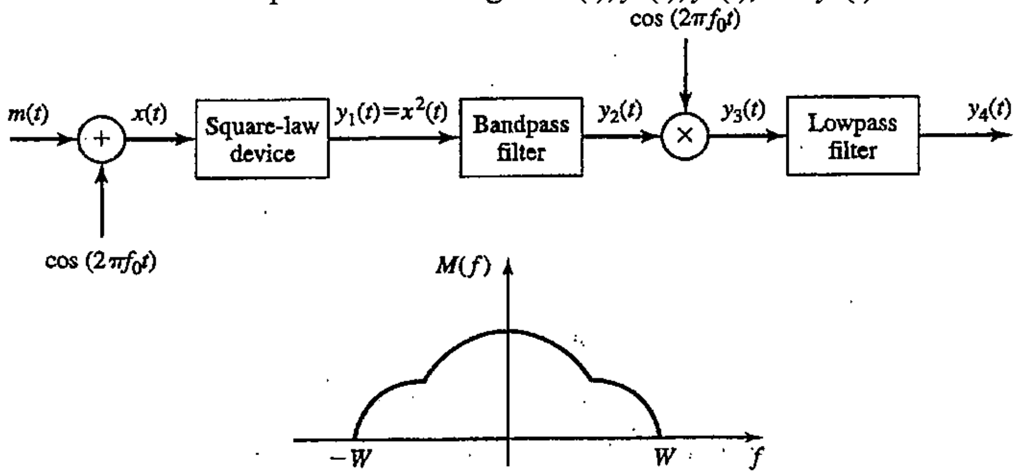

Figure Q2(b)

[8 marks]

(c) Briefly explain the reason for single sideband (SSB) modulation scheme being unsuitable for video and computer data transmission. State the available modulation scheme for such transmission.

[2 marks]

(d) State the **TWO** methods used to determine bandwidth in FM.

[2 marks]

(e) An angle-modulated signal is described as:

$$x(t) = 10\cos\left[2\pi(10^6)t + 0.1\sin(10^3)\pi t\right]$$

(i) Considering $x(t)$ as a PM signal with phase deviation constant $k_p = 10$, find $m(t)$.

(ii) Considering $x(t)$ as an FM signal with frequency deviation constant $k_f = 10\pi$, find $m(t)$.

[8 marks]

Continued ...

Question 3

(a) A 4-bit PCM system is applied to digitize a signal represented, which is represented as $m(t) = 5\sin(2\pi t)$. This linear midrise quantizer has a step-size Δ of 1 V. Sketch the resulting PCM wave for one complete cycle of the $m(t)$ input signal, assuming a sampling rate of four samples per second, with samples taken at $t = 1/8, 3/8, 5/8, ...$ seconds.

[10 Marks]

(b) An information signal is fed into a uniform PCM system, which uses a 8-bit encoder and produces an output signal at a rate of 48 Mbps.

(i) Determine the bandwidth of the analog signal if the system operates at minimum sampling rate.

[3 Marks]

(ii) Find the output signal-to-quantisation noise ratio if the analog signal is a full-load sinusoidal wave of frequency 1 MHz.

[3 Marks]

(c)

A message signal

$$m(t) = \cos(1500\pi t) + \cos(500\pi t)$$

for a DM system, which is designed for audio signal of up to 3400 Hz, is sampled at 64 kHz.

(i) Calculate the minimum value of the step size Δ to avoid slope overload.

[3 Marks]

(ii) Find the granular-noise power N_o.

[3 Marks]

(iii) With the noise power found in (ii), determine the SNR.

[3 Marks]

Continued ...

Question 4

(a) One of the main disturbances in communication systems is intersymbol interference (ISI).

(i) Define ISI.

(ii) Sketch a figure showing the effects of ISI on the received bits.

(iii) Briefly describe two approaches that can be taken to combat and control ISI.

[2+4+4 Marks]

(b) A 9,600 bits/s data terminal is connected to a modem. Calculate the transmission bandwidth required and the baud rate at the modem output for each of the following schemes. 50% roll-off shaping is used in all cases

i) 4-QAM

ii) 16-QAM

iii) QPSK

iv) PSK

[3+3+3+2 Marks]

(c) A telephone circuit is assumed to be modeled as an AWGN channel with a bandwidth of 5 kHz.

(i) Determine the capacity of this circuit if the SNR is 20 dB.

(ii) Determine the SNR required for an error-free transmission rate of 6000 bits/s.

[2+2 Marks]

Continued ...

Appendix I

Trigonometric Preliminaries

1. $\sin(n\pi) = 0,\ n = \text{integer}$
2. $\cos(n\pi) = (-1)^n = \begin{cases} 1, & n = even \\ -1, & n = odd \end{cases}$
3. $\sin^2 x = \frac{1}{2}(1 - \cos 2x)$
4. $\cos^2 x = \frac{1}{2}(1 + \cos 2x)$
5. $\sin x \sin y = \frac{1}{2}[-\cos(x+y) + \cos(x-y)]$
6. $\cos x \cos y = \frac{1}{2}[\cos(x+y) + \cos(x-y)]$
7. $\sin x \cos y = \frac{1}{2}[\sin(x+y) + \sin(x-y)]$

Continued ...

Appendix II

Fourier Transform Pairs

$x(t)$	$X(f)$
$\delta(t)$	1
$\delta(t-t_o)$	$e^{-j2\pi f t_o}$
1	$\delta(f)$
$e^{j2\pi f_o t}$	$\delta(f-f_o)$
$u(t)$	$\frac{1}{2}\delta(f)+\frac{1}{j2\pi f}$
$e^{-at}u(t)$	$\frac{1}{a+j2\pi f}$, for $a>0$
$e^{at}u(-t)$	$\frac{1}{a-j2\pi f}$, for $a>0$
$e^{-a\|t\|}$	$\frac{2a}{a^2+(2\pi f)^2}$, for $a>0$
$t^n e^{-at}u(t)$	$\frac{n!}{(a+j2\pi f)^{n+1}}$, for $a>0$
$rect\left(\frac{t}{T}\right)$	$T\mathrm{sinc}(fT)$
$\mathrm{sinc}(2Wt)$	$\frac{1}{2W}rect\left(\frac{f}{2W}\right)$
$\Delta\left(\frac{t}{T}\right)$	$\frac{T}{2}\mathrm{sinc}^2\left(\frac{fT}{2}\right)$
$W\mathrm{sinc}^2(Wt)$	$\Delta\left(\frac{f}{2W}\right)$
$e^{-\pi t^2}$	$e^{-\pi f^2}$

Continued ...

Appendix III

Fourier Transform Pairs and Properties

$\cos(2\pi f_o t)$	$\frac{1}{2}\delta(f-f_o)+\frac{1}{2}\delta(f+f_o)$
$\sin(2\pi f_o t)$	$\frac{1}{2j}[\delta(f-f_o)-\delta(f+f_o)]$
$\mathrm{sgn}(t)=\begin{cases}1 & t>0\\ -1 & t<0\end{cases}$	$\frac{1}{j\pi f}$
$\frac{1}{\pi t}$	$-j\,\mathrm{sgn}(f)$
$\sum_{i=-\infty}^{\infty}\delta(t-iT_o)$	$\frac{1}{T_o}\sum_{n=-\infty}^{\infty}\delta(f-\frac{n}{T_o})$
$e^{-at}\cos(2\pi f_o t)u(t)$	$\frac{a+j2\pi f}{(a+j2\pi f)^2+(2\pi f_o)^2}$, for $a>0$
$e^{-at}\sin(2\pi f_o t)u(t)$	$\frac{2\pi f_o}{(a+j2\pi f)^2+(2\pi f_o)^2}$, for $a>0$

Let $x(t)\Leftrightarrow X(f)$, $x_1(t)\Leftrightarrow X_1(f)$ and $x_2(t)\Leftrightarrow X_2(f)$; and a, b, t_o and f_o scalar quantities.

Linearity	$ax_1(t)+bx_2(t)\Leftrightarrow aX_1(f)+bX_2(f)$
Conjugation	$x^*(t)\Leftrightarrow X^*(-f)$
Duality	$X(t)\Leftrightarrow x(-f)$
Scaling ($a\neq 0$)	$x(at)\Leftrightarrow \frac{1}{\lvert a\rvert}X\left(\frac{f}{a}\right)$
Time Shifting	$x(t-t_o)\Leftrightarrow X(f)e^{-j2\pi f t_o}$
Frequency Shifting	$x(t)e^{j2\pi f_o t}\Leftrightarrow X(f-f_o)$
Modulation	$x(t)\cos(2\pi f_0 t)\Leftrightarrow \frac{1}{2}X(f-f_0)+\frac{1}{2}X(f+f_0)$
Time Differentiation	$\frac{d^n}{dt^n}x(t)\Leftrightarrow (j2\pi f)^n X(f)$
Frequency Differentiation	$(-jt)^n x(t)\Leftrightarrow \frac{d^n}{df^n}X(f)$

Continued ...

Appendix IV

Bessel Function Table

n	$\beta = 0$	$\beta = 0.05$	$\beta = 0.1$	$\beta = 0.2$	$\beta = 0.3$	$\beta = 0.5$	$\beta = 0.7$	$\beta = 1$	$\beta = 2$	$\beta = 3$	$\beta = 5$	$\beta = 7$	$\beta = 8$	$\beta = 10$
0	1.000	0.999	0.998	0.990	0.978	0.938	0.881	0.765	0.224	-0.260	-0.178	0.300	0.172	-0.246
1		0.025	0.050	0.100	0.148	0.242	0.329	0.440	0.577	0.339	-0.328	-0.005	0.235	0.043
2			0.001	0.005	0.011	0.031	0.059	0.115	0.353	0.486	0.047	-0.301	-0.113	0.255
3					0.001	0.003	0.007	0.020	0.129	0.309	0.365	-0.168	-0.291	0.058
4							0.001	0.002	0.034	0.132	0.391	0.158	-0.105	-0.220
5									0.007	0.043	0.261	0.348	0.186	-0.234
6									0.001	0.011	0.131	0.339	0.338	-0.014
7										0.003	0.053	0.234	0.321	0.217
8											0.018	0.128	0.223	0.318
9											0.006	0.059	0.126	0.292
10											0.001	0.024	0.061	0.207
11												0.008	0.026	0.123
12												0.003	0.010	0.063
13												0.001	0.003	0.029
14													0.001	0.012
15														0.005
16														0.002
17														0.001

	N		N		N		N
$\beta = 0.05$	1	$\beta = 0.7$	4	$\beta = 5$	10	$\beta = 20$	28
$\beta = 0.1$	2	$\beta = 0.8$	4	$\beta = 6$	12	$\beta = 25$	34
$\beta = 0.2$	2	$\beta = 0.9$	4	$\beta = 7$	13	$\beta = 30$	39
$\beta = 0.3$	3	$\beta = 1$	4	$\beta = 8$	14	$\beta = 35$	45
$\beta = 0.4$	3	$\beta = 2$	6	$\beta = 9$	15	$\beta = 40$	50
$\beta = 0.5$	3	$\beta = 3$	7	$\beta = 10$	17	$\beta = 45$	55
$\beta = 0.6$	3	$\beta = 4$	9	$\beta = 15$	22	$\beta = 50$	61

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